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Chemicals*

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* Major chapter revision.

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Chemicals

21.01 Introduction

The chemicals discussed in this chapter include generic chemicals, elements, and compounds identified by their proper name and trade name products that contain one or more chemicals that are hazardous (such as cleaning products, solvents, and lubricants). Many chemicals are poisonous, irritating, corrosive, carcinogenic, pyrophoric, or explosive (having two or more of these properties is not uncommon). Chemicals that may be relatively safe when used alone can become very dangerous when mixed with other substances, either in a planned experiment or by accident. Therefore, personnel who use, store, dispose of, or transport chemicals must consider the hazards and use appropriate controls and procedures.

While specific chapters of this manual deal with particular kinds of chemical hazards, this chapter is intended to provide the user of chemicals with general guidelines on safe use and disposal of such chemicals. Detailed information can be found in the specific chapters referenced and in the supplements. Specific requirements of “controlled materials” are discussed in Chapter 8 of LLNL’s *Health & Safety Manual*.

21.015 Chemical Hygiene Plans and Health Hazard Communication

The Occupational Safety and Health Administration (OSHA) and U.S. Department of Energy (DOE) require that all employees who handle or work around hazardous materials be informed of their hazards and be trained in safe handling techniques. Although regulations differentiate between the research laboratory and shop, maintenance, or production workplaces, some of the key requirements are the same.

In any work area where hazardous substances are present, there must be a plan for identifying and labeling hazards, maintaining collections of material safety data sheets (MSDSs), providing ongoing training on hazard recognition and control, and notifying employees of their rights to obtain safety information. Additional require-

ments cover topics such as the use of personal protective equipment, medical surveillance, and emergency planning.

Implementation of these programs at LLNL is described in Supplements 1.02 (to be renumbered as Supplement 7.02) and 21.01 of this manual. One or the other of these documents applies to all chemical handling at the Laboratory, depending on the nature of the operation. Research laboratories must follow Supplement 21.01; all other areas must follow Supplement 7.02.

For the purposes of these regulations, laboratory use of hazardous materials must include the following conditions:

- Manipulations are carried out on a laboratory scale;
- Multiple chemical procedures or chemicals are used;
- Procedures are not part of a production process; and
- Protective practices and equipment are available and in common use to minimize employee exposure.

Examples of research activities are chemical, biomedical, and materials science laboratories. Not included would be photoprocessing, electronics, or routine testing laboratories. Contact the industrial hygienist from your area ES&H team (formerly known as the safety team) for further guidance on the applicability of these requirements.

21.02 Planning

The user must evaluate each task in which chemicals are used to determine the associated risk. This evaluation must include a consideration of the properties and reactivity of the chemicals or combination of chemicals. Additionally, disposal options and waste minimization techniques should also be considered in the planning stage. Further, the tasks and chemicals involved should be reviewed by a knowledgeable person in advance of the operation. See Chapter 2 of this manual to determine whether a safety procedure is needed.

21.03 Responsibilities

Supervisors are responsible for establishing safe procedures, enforcing LLNL, state, and federal regulations, and providing the protective equipment and clothing needed in handling chemicals. They must instruct their personnel as to the possible hazards, safety precautions, waste handling, and actions to take in case of an accident. It is also the supervisor's responsibility to assure that employees are held accountable for the chemicals they work with. In case of a job transfer or termination, employees must properly dispose of or transfer all chemicals to another responsible party before leaving.

Employees are required to be familiar with the properties of the chemicals they work with and follow all safety procedures. In cases of malfunction or damage or if injury occurs, the employee should act to protect himself/herself and others in the area. Employees shall report any unsafe or hazardous condition in the area to the supervisor.

The Hazards Control Department, through its ES&H teams, assists supervisors and employees in maintaining safe work areas by providing information on the hazardous properties of materials and relevant regulations, recommending methods for control, and monitoring the work environment. Hazards Control maintains a file of MSDSs (see Section 21.035) and a library of current regulations and offers formal education and training courses. See Chapter 7 in this manual for safety courses on chemical hazards. Hazards Control also maintains all monitoring results and makes this information available to supervisors and Health Services.

21.031 Chemical Inventories

Current regulations require written chemical inventories, and changes to regulations that could affect inventories are frequently proposed. Hazards Control recommends that each chemical or product be identified in a formal inventory, although this is not strictly required at this time for all materials in all areas. The following are inventory requirements for research laboratories:

- List each chemical carcinogen and/or reproductive toxin.
- List each chemical by name, type of container (glass, polyethylene, etc.), and quantity stored. If you have any questions, contact the environmental analyst for your area ES&H team.

- List hazards by generic categories when present: corrosive, flammable, oxidizer, explosive, highly toxic, and reactive.

A complete inventory must be compiled for non-laboratory areas (e.g., shops) and updated at least annually. This inventory requirement should be specified in facility safety procedures (FSPs) to provide guidance to building occupants. For the most current requirements, contact the industrial hygienist and environmental analyst from your ES&H team.

21.035 Material Safety Data Sheets

Federal hazard communication laws require chemical manufacturers to prepare MSDSs for their products. Each data sheet provides detailed information on the physical, chemical, and physiological properties of a particular chemical and on the recommended control procedures to be used during handling. Requirements for obtaining MSDSs and keeping files of them available to employees in the workplace are different for laboratories, shops, and storerooms. Supervisors should obtain a copy of Supplement 7.02 of this manual for detailed information. Training course HS-4050 is available on this subject and shall be taken by all supervisory personnel. Supervising chemists shall take HS-4052. Course HS-4050 or HS-4052 should also be taken by all employees and contractors.

If a manufacturer's MSDS lacks the information needed for safe use of the material, the supervisor should request assistance from his/her ES&H team. The manufacturer will be contacted for more information, as required, and a supplemental MSDS may be prepared. When a material of unknown toxicity (MOUT) is developed at LLNL, an MSDS shall be prepared before the material may be shipped off site.

21.04 Facilities and Equipment

Adequate facilities, clothing, and the equipment necessary to control the hazards related to specific chemical operations must be obtained before work is started. General requirements for areas using chemicals include the following:

- Install cabinets and shelving for chemical storage, as indicated in Section 21.045.
- Install an approved-type safety shower and eyewash station (see Section 6.05 of this manual for specifications).

- Use local-exhaust ventilation fume hoods or close-capture systems for any experiment that produces hazardous quantities of gas, vapor, or airborne particulates in the work environment. Such ventilation must be the “once-through” type that permits no recirculation of exhaust air.
- Cover floors and bench-top surfaces with impermeable materials for easy cleanup of spilled chemicals (see also Section 6.09 of this manual).
- Use face shields, safety goggles, liquid-proof aprons, and gloves when handling containers of corrosive chemicals (see Supplement 21.15).
- Provide containers for uncontaminated broken glass.
- Dispose of used hypodermic syringes by placing them in an appropriate sharps container.

21.045 Storage of Chemicals

General requirements for chemical storage areas are as follows:

- Provide fresh-air ventilation (e.g., 10 to 15 air changes per hour).
- Install cabinets and shelving for chemical storage using the tie-down standard details developed by Plant Engineering. Use shelf bars (Central Supply Stock Nos. 5340-64210 and -64653) to keep chemical containers on shelves during an earthquake.
- Clearly label the storage area and each container. Container labels must give the chemical name, type of hazard, special precautions, and emergency information. Appendix 21-A provides an overview of several labeling formats commonly used. Labels for common chemicals are available from Central Supply or your area ES&H team. Your ES&H team can also assist you with any unique labeling problems.
- Separate incompatible chemicals by physical barriers to prevent accidental mixing, as might happen in an earthquake. For example, the following classes of chemicals are mutually incompatible: acids, bases, oxidizers, flammables, toxics, and water reactives. Contact your area ES&H team for information on specific chemicals. Copies of the storage precaution signs in

Appendix 21-B also can be obtained from your ES&H team.

- Provide a means to contain spills (e.g., trays), particularly of liquids in glass containers.
- Limit quantities of materials in storage and in use to the minimum necessary (waste minimization). Observe shelf-life limits (see Section 21.055).
- See Chapter 25 of this manual for storage of flammable liquids.
- Chlorinated hydrocarbons such as trichloroethylene, methylene chloride, 1,1,1-trichloroethane, and perchloroethylene (tetrachloroethylene) have special storage requirements to help prevent environmental pollution:
 - Areas that do not use significant amounts of chlorinated solvents should store them indoors in relatively small containers, using the guidelines for chemical safety found in this chapter and Appendix 21-B.
 - Use of 55-gal drums is not recommended; use of refillable safety cans is preferred. Areas that *must* use 55-gal drums of chlorinated solvents *shall* store them in a facility that has the following characteristics:
 1. Is dry, well ventilated, completely covered, and lighted (a shed with openings for light and air would suffice).
 2. Is designed so that spills drain to a holding area (pan, berm, etc.) that is leakproof, holds 55 gal, and is protected from rain.
 3. Allows storage of drums in a *vertical* position.
 4. Uses a Protectoseal Model H4500N drum-transfer pump with drip-return pan or equivalent (available from California Safety and Supply Co., Santa Clara, CA).
 5. Has an entrance easily accessible by manual drum-handling devices.

An alternative to constructing this facility is to store 55-gal drums in existing buildings that meet the same requirements. The 55-gal-capacity, spill-containment requirement can be waived in this case, as long as the building is regularly occupied and no floor drain to the sanitary sewer exists in the storage room. Protectoseal storage cabinets, Models 5555 (one drum)

and 555W (two drums), or the equivalent, must be used. These cabinets are not designed for outside use and do not provide the 55-gal spill containment required for outdoor storage.

- Every chemical storage area shall have a person designated to inspect the area and assure good maintenance. A method for contacting the responsible person should be set up.

Plant Engineering has experience in designing facilities to meet the above requirements. Contact your Plant Engineering field team for more information.

21.05 Handling Solid and Liquid Chemicals

The number of chemicals and their hazardous properties and reactions are so extensive that even chemists are still discovering “new” properties and reactions. Therefore, if the properties of a chemical are not fully known, it should be considered hazardous. Test the chemical, using the smallest possible quantity to minimize the effects of unexpected accidents. In addition to this, observe the following safety precautions when working with chemicals:

- Keep the work area clean and orderly.
- Do not eat, drink, smoke, apply cosmetics, or store food in the work area. Read all container labels and, if necessary, the MSDSs.
- Use required safety equipment. The minimum protective clothing is a laboratory coat and safety glasses; for additional protection, wear gloves and a face shield.
- Isolate hazardous operations in separate rooms; limit the number of personnel involved.
- Whenever possible, select chemicals that are the least hazardous.
- Use mechanical aids for all pipetting procedures (e.g., pipette with rubber bulb; Central Supply Stock No. 6640-19457).
- Limit the volume of volatile or flammable materials to the minimum required for short operations.
- Provide a means for containing the material if the equipment or containers break or spill their contents.
- Provide safe, conveniently located sinks and hand cleaners. (Do not use solvents.)

- If the operating system is used under pressure or can generate pressure, follow the requirements in Chapter 32 of this manual.

21.055 Peroxidizable Materials

Peroxidizable materials form unstable peroxides when they are in the presence of oxygen, stored for long periods of time, or exposed to sunlight. These mixtures may explode when disturbed, when the caps are removed from their containers, or when the chemicals are used. Peroxides also tend to accumulate even if preservatives or inhibitors are added to slow down the peroxidization process. Thus, these chemicals should be protected from exposure to light, heat, and air.

In addition, peroxides should be stored in accordance with the times specified in Table 21-1. Old containers of peroxide-forming chemicals that are improperly stored are most likely to be dangerous, especially if discoloration, crystallization, or layering is observed. If there is reason to believe that dangerous levels of peroxides may be present in a container, immediately contact the Fire Department (dial 911). The Fire Department will handle the chemical until it is determined that it is not an imminent hazard.

Each container of peroxidizable chemical must be labeled with the date received and the date opened. Central Receiving will apply special warning labels (Fig. 21-1) and a receipt date to new shipments of selected peroxide-forming chemicals that are commonly used. However, the end user is ultimately responsible for labeling the containers. Labels are available from the ES&H team.

Containers must also be assigned an appropriate expiration date, which may be either 18 months after the unopened container is received or, depending on the chemical, a date usually between 3 and 12 months after the container is opened, whichever is sooner. At expiration, each container of peroxide-forming chemical either must be tested for the peroxide content or assumed to contain excessive peroxides and disposed of as hazardous waste. The maximum allowable concentration of peroxide chemicals is 100 ppm. If a value of 100 ppm of peroxide is detected, the owner may choose to deperoxidize the chemical or dispose of it as hazardous waste.

Some deperoxidizing methods are inherently dangerous, and some fail to remove higher peroxides (e.g., dioxane) in chemicals. As many deperoxidization methods are available, select

Table 21-1. Common chemicals that form explosive levels of peroxides and their storage limits. ^a

Without concentration (3-month storage)	Peroxidizable chemicals	
	On concentration ^b (12-month storage)	Autopolymerize (24 hr–12 month storage) ^c
Butadiene ^d	Acetal	Acrylic acid
Chloroprene ^e	Acetaldehyde	Acrylonitrile
Divinyl acetylene	Benzyl alcohol	Butadiene ^f
Isopropyl ether	2-Butanol	Chloroprene
Potassium metal	Cyclohexanol	Chlorotrifluoroethylene
Sodium amide	2-Cyclohexene-1-ol	Methyl methacrylate
Tetrafluoroethylene ^e	Cumene	Styrene
Vinylidene chloride	Decahydronaphthalene	Tetrafluoroethylene
	Diacetylene	Vinyl acetate
	Dicyclopentadiene	Vinyl acetylene
	Diethyl ether	Vinyl chloride
	Diethylene glycol dimethyl ether	Vinyl pyridine
	Dioxanes	
	Ethylene glycol dimethyl ether	
	4-Heptanol	
	Methyl acetylene	
	Methyl isobutyl ketone	
	3-Methyl-1-butanol	
	Methylcyclopentane	
	2-Pentanol	
	4-Pentene-1-ol	
	1-Phenylethanol	
	2-Phenylethanol	
	2-Propanol	
	Tetrahydrofuran	
	Tetrahydronaphthalene	
	Vinyl ethers	
	Other secondary alcohols	

^a Other materials than those listed may form peroxides. Contact your ES&H Team for further information.

^b May become unstable if concentrated by the user.

^c Chemicals to be stored for 24-hours if uninhibited or 12 months if inhibited.

^d When stored as an inhibited liquid monomer.

^e When stored as a liquid monomer.

^f When stored as a gas.

<p align="center">WARNING: MAY FORM EXPLOSIVE PEROXIDES</p> <p>Store in tightly closed original container. Avoid exposure to light, air, and heat. If crystals, discoloration, or layering is visible, contact your ES&H team immediately. Check for peroxides before distilling or concentrating.</p> <p align="center">THIS CHEMICAL HAS A LIMITED SHELF LIFE</p> <p>Container received on: _____</p> <p>Container opened on: _____</p> <p align="center">Test or dispose of _____ months after receipt or _____ months after opening.</p> <p align="center">TESTING, DEPEROXIDATION AND STABILIZATION RECORD</p> <p>Test Date _____ Peroxides _____ Post treatment _____ Inhib. Added _____</p> <p>Test Date _____ Peroxides _____ Post treatment _____ Inhib. Added _____</p> <p>Test Date _____ Peroxides _____ Post treatment _____ Inhib. Added _____</p>

Figure 21-1. Warning label for peroxide-forming materials.

the one most suitable for the material's intended use. Also, test the material after completing the deperoxidation procedure to ensure its effectiveness. A deperoxidized chemical may be redated as if it was just opened.

Contact your ES&H team for procedures for testing, deperoxidizing, and disposing of peroxidizable chemicals.

21.06 Handling Gases

Considerable care should be used in handling gases. When released into the work environment, toxic gases may be inhaled or come in contact with unprotected human tissue. Employees who work with gases should be familiar with their properties and their reaction with the human body. In addition, gases may be corrosive, flammable, explosive, or radioactive, as the following examples illustrate:

- Acetylene is incompatible with silver, mercury, or copper and, under certain conditions, may react explosively with any of them.
- Nickel carbonyl is very toxic, even at low concentrations.
- In low concentrations, chlorine is corrosive to metals as well as to human tissue.
- Because gases are usually supplied in cylinders under pressure, employees should be familiar with Section 32.10 of this manual. For detailed information on specific gases, especially those that are toxic,
 - Check supplements to this manual;
 - See *Matheson Gas Data Book* and *Fire Protection Guide on Hazardous Materials* (National Fire Protection Association; Central Supply Stock No. 7510-59172); or
 - Contact a member of your area ES&H team for information and guidance.

21.07 Waste Minimization

Waste minimization is important because it helps protect the environment, while also reducing the great expense and administrative difficulties associated with disposing of hazardous wastes; *waste minimization doesn't cost—it pays*. Waste minimization means limiting inventories and the use of hazardous materials to quantities as small as possible, which improves safety wherever hazardous materials are stored and used.

Waste minimization begins when planning any experiment or job. Plan to use the smallest vessels, apparatus, or equipment that are practical and safe to do a given task. Try to eliminate or minimize generating "surplus chemicals." Choose equipment and techniques that (1) use the least hazardous material available, (2) use the smallest quantities of hazardous materials, (3) generate the least amount of hazardous waste, and (4) are practical and safe to do any given task.

Other ways of minimizing hazardous waste are given below:

- *Share inventories* of hazardous chemicals with other users in the area. This reduces duplication of hazardous materials and reduces hazardous waste generation because the entire group can maintain a reserve rather than each member having his/her own. This means that fewer containers will reach the end of their shelf lives or be discarded when a particular user no longer needs a specific hazardous material.
- *Reuse* hazardous materials whenever possible. Select procedures and equipment that allow hazardous materials to be reused whenever this is practical and safe.
- *Transfer your surplus hazardous materials*, if possible, to others in the Laboratory who can use them before you dispose of them.
- *Dispose of hazardous materials promptly* at the end of their shelf lives. Test hazardous materials that have reached their shelf-life limits (1) to determine that they are still useful if you still need the material and (2) whenever such retesting is practical. Supervisors/principal investigators, building managers, and building coordinators shall not allow unlabeled containers or cylinders to accumulate. Personnel moving out of a lab or shop shall dispose of their hazardous materials as hazardous waste before they leave or transfer their unused or partially used hazardous materials to others.
- *Always know what you are using and disposing of*. The identity of items being disposed of must be known prior to disposal; analyzing an unknown material to identify it is usually very expensive and time consuming.
- Contact the environmental analyst for your area ES&H team regarding any questions you may have on implementing waste minimization ideas.

21.08 Chemical Waste Disposal

Waste chemicals and spent chemical solutions produced by LLNL operations can pose a threat to the environment if not properly managed. These hazardous wastes must be disposed of by Hazardous Waste Management. Before disposing of any chemicals, contact your area ES&H team's environmental analyst or hazardous waste tech for guidance in the proper packaging, labeling, and storage of hazardous waste (see Section 4 of the *Environmental Protection Handbook*). Those persons who generate or handle hazardous waste must attend training presented by the Environmental Protection Department (course EP-0006).

21.09 Chemical Spills

Detailed information about spills of specific chemicals can be found in the supplements

to this chapter. Small spills of materials normally handled in a given area can usually be cleaned up safely by the employees involved; however, the employee must be trained in advance to handle these cleanups. Materials for cleanup of common chemical spills are available from Central Supply.

Environmental regulations and DOE orders have reporting requirements for chemical spills above certain amounts or when potential harm to individuals, property, or the environment exists. Report all spills of hazardous chemicals to the health and safety technician and environmental analyst for your area.

If the spill is too large to clean up safely or if employees have been injured or contaminated, immediately call the Laboratory emergency number (911 or ext. 2-7333 at Livermore; 911 or ext. 3-5333 at Site 300). The LLNL Fire Department operates a "Haz Mat" (hazardous material) truck to respond to major spills.

Appendix 21-A

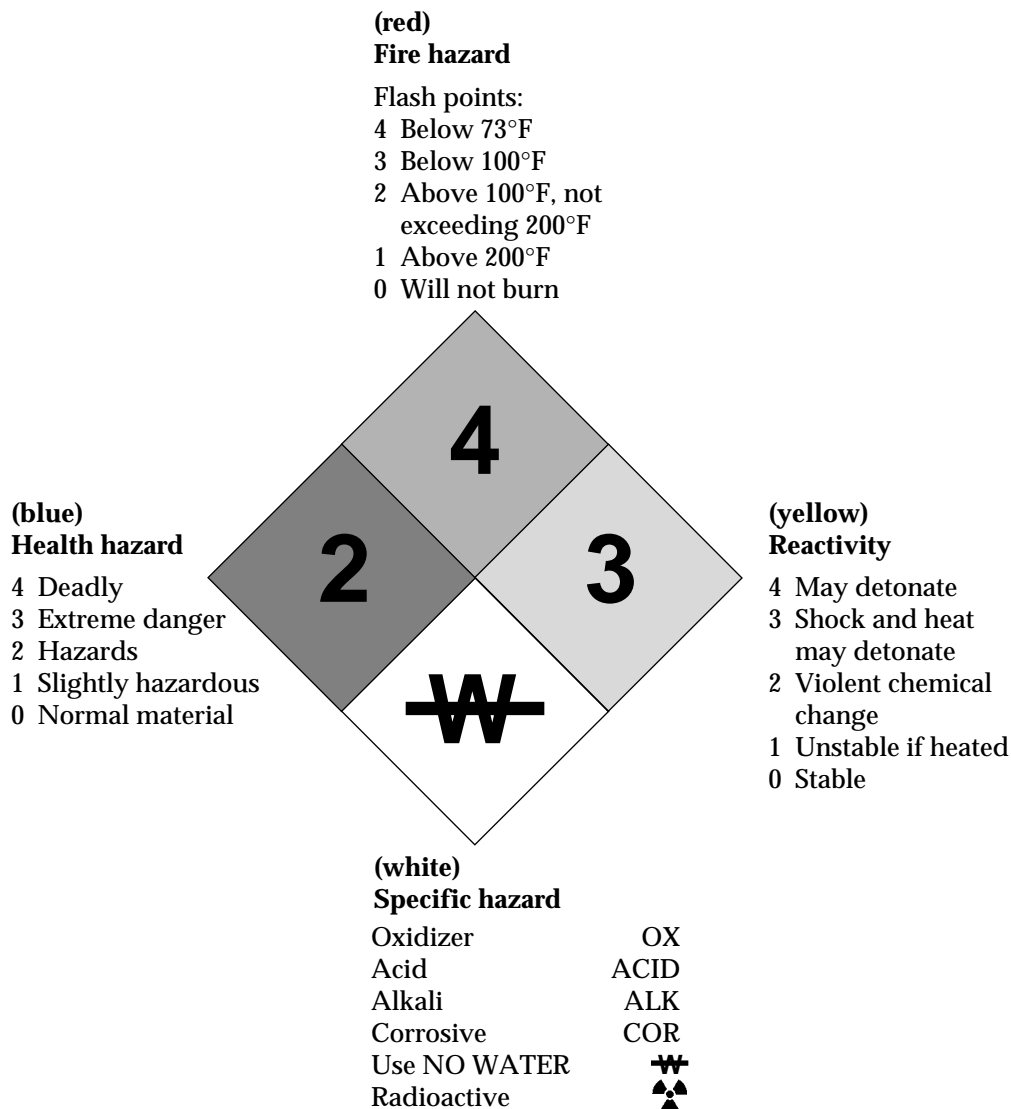
Labeling Formats for Chemical Containers

HMIS—Hazardous Material Identification System, a labeling system that uses letters, numbers, and symbols to communicate hazard information. The following example explains how to read the label.

ACETONE	
HEALTH	1
FLAMMABILITY	3
REACTIVITY	2
PERSONAL PROTECTION	

4	Severe hazard
3	Serious hazard
2	Moderate hazard
1	Slight hazard
0	Minimal hazard

NFPA—National Fire Protection Association. The NFPA developed a diamond-shaped label with numbers and symbols to communicate hazard information about chemicals. The example below explains how to read the label.



Appendix 21-B

Storage Precaution Signs for Hazardous Chemicals

Copies of the storage precaution signs on the following pages can be obtained from your ES&H team. These signs should be posted in areas where hazardous chemicals are used.

WATER REACTIVE CHEMICALS

Storage Precautions:

- Store in a cool, dry place.
- In case of fire, keep water away.



WARNING: These chemicals react with water to yield flammable or toxic gases or other hazardous conditions.

Solids

Aluminum chloride, anhydrous	Maleic anhydride
Calcium carbide	Phosphorous pentachloride
Calcium oxide	Phosphorous pentasulfide
Ferrous sulfide	* Potassium
* Lithium	* Sodium
Magnesium	

* Lithium, potassium, and sodium should be stored under kerosene or mineral oil.

Liquids

Acetyl chloride	Stannic chloride
Chlorosulfonic acid	Sulfur chloride
Phosphorous trichloride	Sulfuryl chloride
Silicon tetrachloride	Thionyl chloride

HC Hazards Control



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OXIDIZERS

Storage Precautions:

- Store in a cool, dry place.
- Keep away from flammable and combustible materials (such as paper, wood, etc.).
- Keep away from reducing agents such as zinc, alkaline metals, and formic acid.



Solids

Ammonium dichromate	Nitrates, salts of ⁴
Ammonium perchlorate	Periodic acid
Ammonium persulfate	Permanganic acid
Benzoyl peroxide	Peroxides, salts of ⁵
Bromates, salts of ¹	Potassium dichromate
Calcium hypochlorite	Potassium ferricyanide
Cerric sulfate	Potassium permanganate
Chlorates, salts of ²	Potassium persulfate
Chromium trioxide	Sodium bismuthate
Ferric trioxide	Sodium chlorite
Ferric chloride	Sodium dichromate
Iodates, salts of ³	Sodium nitrite
Iodine	Sodium perborate
Magnesium perchlorate	Sulfates, salts of ⁶
Manganese dioxide	

¹ Potassium bromate, sodium bromate, etc.

² Potassium chlorate, etc.

³ Sodium iodate, etc.

⁴ Ammonium nitrate, ferric nitrate, etc.

⁵ Lithium peroxide, sodium peroxide, etc.

⁶ Ferric sulfate, potassium sulfate, etc.

Liquids

Bromine	Nitric acid
Chromic acid	Perchloric acid
Hydrogen peroxide	Sulfuric acid

Gases

Chlorine	Nitrogen oxide
Chlorine dioxide	Oxygen
Fluorine	Ozone
Nitrogen dioxide	

HC Hazards Control

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PYROPHORIC SUBSTANCES

Storage Precaution:

- Store in a cool, dry place.

WARNING: Pyrophoric substances ignite spontaneously upon contact with air.

Boron	* Iron
* Cadmium	* Lead
* Calcium	* Manganese
* Chromium	* Nickel
* Cobalt	† Phosphorous, yellow
Diborane	* Titanium
Dichloroborane	* Zinc
2-Furaldehyde	

* Finely divided metals form a pyrophoric hazard.

† Phosphorous, yellow, should be stored and cut under water.



LIGHT-SENSITIVE CHEMICALS

Storage Precautions:

- Avoid exposure to light.
- Store in amber bottles in a cool, dry place.

Bromine	Mercurous nitrate
Ethyl ether	Oleic acid
Ferric ammonium citrate	Potassium ferrocyanide
Hydrobromic acid	Silver salts ²
Mercuric salts ¹	Sodium iodide

¹ Mercuric chloride, mercuric iodide, etc.

² Silver acetate, silver chloride, etc.

PEROXIDE-FORMING CHEMICALS

Storage Precautions:

- Store in airtight containers in a dark, cool, and dry place.
- Label containers with receiving, opening, and disposal dates.
- Dispose of peroxide-forming chemicals before expected date of first peroxide formation in accordance with LLNL policy.
- Test for the presence of peroxides periodically.

WARNING: Under proper conditions, these chemicals will form explosive peroxides that can be detonated by shock or heat.

Acetaldehyde	Ethyl ether
Acrylaldehyde	Isopropyl ether
Crotonaldehyde	* Potassium
Cyclohexene	Tetrahydrofuran
p-Dioxane	

* Potassium peroxide often exists in the crust around a chunk of potassium. When cut with a knife, the peroxide rapidly oxidizes the residual kerosene, resulting in an explosion.

FLAMMABLES

Storage Precautions:

- Store in approved safety cans or cabinets.
- Segregate from oxidizing acids and oxidizers.
- Keep away from any source of ignition: flames, localized heat, or sparks.
- Safety cans or drums containing flammable liquids should be grounded and bonded when being used.
- Keep firefighting equipment readily available.
- Have spill cleanup materials handy.
- Store highly volatile flammable liquids in a specially equipped refrigerator.



Solids

Benzoyl peroxide	Phosphorous, yellow
Calcium carbide	Picric acid

Liquids

Acetaldehyde	Ethylamine	Methyl ethyl ketone
Acetone	Ethyl benzene	Methyl formate
Acetyl chloride	Ethylene dichloride	Methyl isobutyl ketone
Allyl alcohol	Ethyl ether	Methyl methacrylate
Allyl chloride	Ethyl formate	Methyl propyl ketone
N-amyl acetate	Furan	Morpholine
N-amyl alcohol	Gasoline	Naphtha
Benzene	Heptane	* Nitromethane
N-butyl acetate	Hexane	Octane
N-butyl alcohol	Hydrazine	Piperidine
N-butylamine	Isobutyl alcohol	Propanol
Carbon disulfide	Isopropyl acetate	Propyl acetate
Chlorobenzene	Isopropyl alcohol	Propylene oxide
Cyclohexane	Isopropyl ether	Pyridine
Diethylamine	Mesityl oxide	Styrene
Diethyl carbonate	Methanol	Tetrahydrofuran
p-Dioxane	Methyl acetate	Toluene
Ethanol	Methyl acrylate	Turpentine
Ethyl acetate	Methylal	Vinyl acetate
Ethyl acrylate	Methyl butyl ketone	Xylene

Gases

Acetylene	Ethylene oxide
Ammonia	Formaldehyde
Butane	Hydrogen
Carbon monoxide	Hydrogen sulfide
Ethane	Methane
Ethyl chloride	Propane
Ethylene	Propylene

* Most nitrohydrocarbons are flammable.

HC Hazards Control

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TOXIC COMPOUNDS

Storage Precaution:

- Store according to hazardous nature of chemical, using appropriate security when necessary.

WARNING: These chemicals are dangerous or extremely dangerous to health and life when inhaled, swallowed, or absorbed by skin contact. Take proper precautionary measures to avoid exposure.



Solids

Antimony compounds	Oxalic acid
Arsenic compounds	Phenol
Barium compounds	Phosphorous, yellow
Beryllium	Phosphorous pentachloride
Cadmium compounds	Phosphorous pentasulfide
Calcium oxide	Picric acid
Chromates, salts of	Potassium
Cyanides, salts of	Selenium compounds
Fluorides, salts of	Silver nitrate
Iodine	Sodium hydroxide
Lead compounds	Sodium hypochlorite
Mercuric compounds	

Liquids

Aniline	Hydrochloric acid
Bromine	Hydrofluoric acid
Carbon disulfide	Hydrogen peroxide
Carbon tetrachloride	Mercury
Chloroform	Nitric acid
Chromic acid	Perchloric acid
p-Dioxane	Phosphorous trichloride
Ethylene glycol	Sulfuric acid
Formic acid	Tetrachloroethane
Hydrazine	Tetrachloroethylene
Hydrobromic acid	

Gases

Carbon monoxide	Hydrogen chloride
Chlorine	Hydrogen cyanide
Cyanogen	Hydrogen sulfide
Diborane	Nitrogen dioxide
Fluorine	Ozone
Formaldehyde	Sulfur dioxide
Hydrogen bromide	

H Hazards Control

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ACIDS

Storage Precautions:

- Store in large bottles of acids on low shelf or in acid cabinets.
- Segregate oxidizing acids from organic acids and flammable and combustible materials.
- Segregate acids from bases and active metals, such as sodium, potassium, magnesium, etc.
- Segregate acids from chemicals that could generate toxic gases upon contact, such as sodium cyanide, iron sulfide, etc.
- Use bottle carriers for transporting acid bottles.
- Have Spill Control Pillows or acid neutralizers available in case of acid spills.



* Acetic acid	† Nitric acid
* Benzoic acid	Nitrous acid
* Chloroacetic acid	† Perchloric acid
† Chromic acid	* Phenol
† Hydrobromic acid	Phosphoric acid
Hydrobromous acid	Phosphorous acid
Hydrochloric acid	* Propionic acid
Hydrochlorous acid	* Sulfamic acid
Hydrofluoric acid	* Sulfanilic acid
Hydroiodic acid	† Sulfuric acid
† Iodic acid	Sulfurous acid
Muriatic acid	

* Indicates organic acids.

† Indicates strong oxidizing acids.

BASES

Storage Precautions:

- Segregate bases from acids.
- Store solutions of inorganic hydroxides in polyethylene containers.
- Have Spill Control Pillows or caustic neutralizers available for caustic spills.

Ammonium hydroxide	Calcium hydroxide
Bicarbonates, salts of ¹	Potassium hydroxide
Carbonates, salts of ²	Sodium hydroxide

¹ Potassium bicarbonate, sodium bicarbonate, etc.

² Calcium carbonate, sodium carbonate, etc.

HC Hazards Control

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